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ABSTRACT

This paper discusses issues of representation in the use of scientific visualizations, specifically those used for biomedical applications, and the implications of those issues to interface design. Topics addressed include the benefits of research into the generation of virtual simulation (virtual reality) and the importance of realism. (Contains 19 references.) (SLD)

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Visual Simulations: Why We Need Pretty Pictures

by
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Introduction

The practice of using computers to previsualize, diagnose, and teach complex biomedical phenomenon is in its infancy. As technology grows, the possibilities for our elucidating the phenomenon of man are rapidly expanding. The ability to create a virtual representation of our world and to perform untold operations to that model, has lead to new areas of scientific, artistic, and educational inquiry. The ability to generate virtual simulations may possibly prove to be one of the most significant developments of our century.

This paper discusses the issues of representation in the use of scientific visualizations, specifically those used for biomedical applications, and the implications of those issues to interface design.

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Virtual Reality - Improved Methods for Information Exchange

With the emergence of most new technologies there follows a period of unrestrained claims of promise. Fortunately, with time, a more sober disposition prevails and our perceptions of the technology are tempered and become more realistic. In order to demythologize new technologies, we must democratize them. As with the personal computer, by democratizing virtual technology, we shall come to see what washes out, and what bears out.

Recently there has been an increased interest in these technologies that enable individuals to create "virtual realities" (VR), "synthetic realities" or "virtual environments". The benefits of research into the generation of virtual simulation are obvious. The application of

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computer graphics for simulating flight have improved flight training significantly. However, certain questions remain: How realistic does the imagery need to be? Where does significant image quality become a hinderance to comprehension and transfer, and where and how does it facilitate the process?

There is mounting interest in using computer technology for creating surgical previsulizations [1][2]. The implications of creating imagery from various imaging sources and providing a non-threatening environment for clinical exploration and education are profound.

However, the current level of the quality of graphics is limiting. Graphics produced by the best VR systems are rather crude, although they are produced in real-time. In order for the technology to become practical to the medical community, the quality and level of representations will need to be greatly improved.

Importance of Realism

A common retort one will often hear when discussing the quality of computer generated images is "We're not just interested in pretty pictures". Somehow it is perceived that images that contain both a high level of technical and aesthetic achievement are fancy, cute and unnecessary, and that the embellishments are distracting and superfluous. This "unnecessary" information, however, may assist the individual in assimilating novel information by contributing visual and temporal cues that create a meaningful context for the content.

Computer technology and algorithm development have reached a state where sophisticated imagery can readily be attained, some in real-time. Images that include detailed spatial and color cues, as well as motion, convey information that the brain expects to see. It is this additional "fluff", as it is often pejoratively termed, which facilitates the brain to rapidly encode the image.

This does not mean to say that all imagery must convey all perceptual cues. Motion may not be required for full comprehension. The elimination of certain cues can create an interesting image, a cognitive closure if you will, that can engage and further stimulate the brain. Such examples may be found within the rich and varied history of art and design.

Recent investigations have explored levels of representations for facilitating learning, most specifically computer generated imagery [3]. Foley has demonstrated that there is a limit to the perceptual cues needed by an individual to do certain recognition tasks [4]. In his study, faceted shaded objects allow the user to match a structure with its rotated counterpart, by an increase of 20 percent over hidden line. Smooth shaded objects, however, offered no improvement for recognizing rotated objects.

More recent research by Lintern has shown that simple graphics may be more helpful to novice flyers when using simulations, and that they may actually reduce practice time by 15 percent [5]. Lintern suggests that the realistic displays may be too distracting for the user and sometime overwhelm them, causing them to panic. This may be true; however, the question may be asked "When do you need increased realism to convey a more

accurate depiction of the task?" Eventually one would want to train on a system that provides enough realism in the simulated environment to maximize transfer to the "real world" situation. Experts may subtly (intuitively) use nuances in the environment to effectively assess and interact with their environment.

Importance of Realism to Medicine

It has been more difficult to convince radiologists to become interested in utilizing three dimensional reconstructions from imaging techniques that it has been to convince surgeons. This is not meant to be disparaging towards radiologists. Most radiologists are trained to discern information from two dimensional imagery. From practice and experience, they have developed an incredible acuity to transform two dimensional information into three dimensions. However, surgeons may not share this discernment. They do not interact with two dimensional images, they interact with three dimensional structures, often of incredible complexity.

Surgery, like anatomy, is a visual art. Both require the utilization of dimensional perception for comprehending the structures. It is difficult for surgeons to transfer information based upon two dimensional images into a three dimensional referent, a latent, or stored representation as defined by Crick and Koch[6]. It is this latent representation with which they will correlate their actions.

In the application of computer graphics to biomedical simulations, the need for realism is obvious. The task is to create the most accurate representation that requires minimal transfer. Complex reticular structures such as the brachial plexus, or regions of the vascular system may require motion to understand the structure adequately. Still images, and images with limited perceptual cues, are inadequate for discerning structural complexity.

Clinical medicine and medical education would be greatly facilitated by using realistic three dimensional referents The dimensional complexities that confronts the surgeon are immense. A common fear of many surgeons is to hear themselves say "I wish I would have known this situation before I opened the patient". The creation of virtual simulations can greatly aid surgical investigation, providing a non-threatening environment for exploration and planning. This is certainly a situation where the fewer surprises, the better.

Surgeons and other clinical investigators whose domains lie in three dimensions are very enthusiastic about the application of three dimensional graphics and simulations to their research and practice. Many surgeries considered inoperable in the past are now becoming tractable. If one has an accurate map with which to build a latent representation, one feels more comfortable in entering hitherto unchartered territory.

Importance of Realism for Transfer

The brain is a wonderful marvel of evolution, an organ that embodies several complex systems that construct a representation of the world around us. As we compare active representations, representations directly perceived, with

latent representations, context becomes extremely important. For the context in which something is viewed affects the way in which it is perceived. By creating more sophisticated imagery, we may facilitate the brain's ability to assimilate novel information by introducing cues that establish links to internally held contexts. These realistic cues may provide the difference between learning and experience. They may aid the individual in participating with content as described by Kay[7]. When the intent is to convey complex and recondite information such as is required in biomedicine, perceptual cues which elucidate the form and context of structures may be essential for the rapid encoding of complex information.

Within a certain domain, most of our perceptions are similar. However, beyond that domain, our perceptions are unique, defined by the unique experiences that each of us undergo. What is required is an interactive interface that permits the individual to titrate the level and complexity of the visual cues provided in a simulation. Studies in cognitive neuroscience have demonstrated physiological mechanisms for individuality[8,9]. We should take advantage of the flexibility of the computer and create interfaces that allow the user to individualize their environment in order to augment their mental capacities. In this way, the user can create the level of realism which provides the visual schema that best suits their understanding and transfer of new information.

Summary

Current theories of perception and cognition maintain that reality is a construct of the brain, that the shared reality we experience may be due to equivalences in genetic makeup. In our shared perceptions, the way in which we see the world represents the brains way of creating representations of our existence that are meaningful. If so, by creating imagery that mimics the way we see, we may augment the assimilation of new information. By building referents that build on natural representations, we may be facilitating the sharing of information across disciplines.

Genetic makeup, however, is congruent only to a degree, and as experiences are unique, so too are the methods in which we perceive. Discoveries in neuroscience have provided a model for the biological expression of individuality. We should respect this diversity and nurture it, for the ability to see the world in new ways provide us with a mechanism of change, a mechanism for both collective and individual growth.

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